Control_Lec8_Report 4

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Q: $G(s) = \frac{K}{s(s+3)(s+6)}$ sec 3

required specs:

$e_{ss} \leq 10$; $\zeta = \frac{1}{2}$; Dominant poles must have real part less than or equal -2

Solution

for real part less than or equal -2

$$\sigma = 2 \Rightarrow \omega_n \zeta = 2 = \omega_n = \frac{2}{\zeta} = \frac{2}{0.5} = 4$$

[1] $s_{1,2} = -\zeta\omega_n \pm j\omega_n\sqrt{1-\zeta^2}$

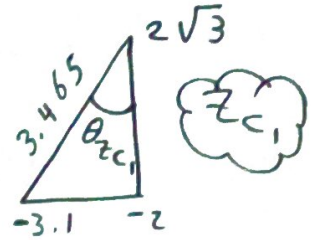
$= -2 \pm j4\sqrt{1-0.5^2} = -2 \pm j2\sqrt{3}$

[2] angle condition: $\angle GH(s) + \phi_{c_1} = -180$

$$\angle \frac{K}{s(s+3)(s+6)}\Big|_{s=-2+j2\sqrt{3}} = -\angle -2+j2\sqrt{3} - \angle 1+j2\sqrt{3} - \angle 4+j2\sqrt{3} + \phi_{c_1} = -180$$

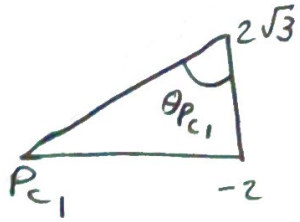
$$\Rightarrow -(180-60) - 73.9 - 40.9 + \phi_{c_1} = -180$$

$$\Rightarrow \phi_{c_1} = 54.8$$



[3] assume $z_{c_1} = -3.1 \Rightarrow$

$$\theta_{z_{c_1}} = \sin^{-1}\frac{|-3.1-(-2)|}{3.465} = 17.17$$



$\theta_{p_{c_1}} = \phi + \theta_{z_{c_1}} = 54.8 + 17.17 \simeq 72$

$$\frac{p_{c_1}-(-2)}{2\sqrt{3}} = -\tan 72$$

$$\Rightarrow p_{c_1} = -\tan(72) * 2\sqrt{3} + (-2) = -12.94$$

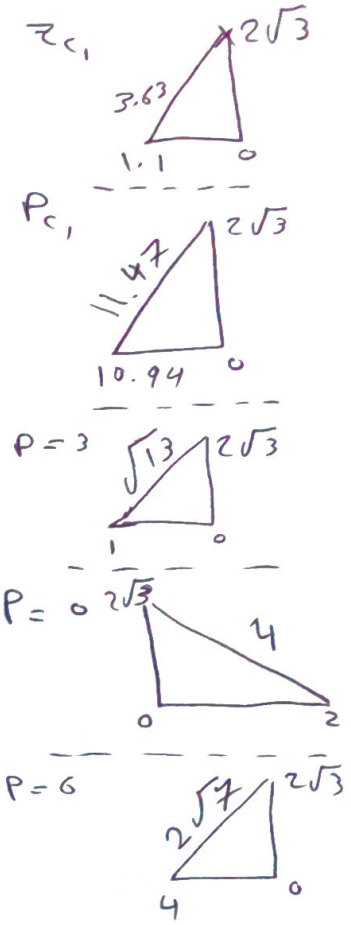
$$G_{c_{lead}} = \frac{S+3.1}{S+12.66} \Rightarrow G(s) = \frac{K(S+3.1)}{S(S+3)(S+6)(S+12.93)}$$

[4] Magnitude condition

$$\| K G(s) \| = 1$$

$$K = \left\| \frac{1}{G(s)} \right\|$$

$$= \frac{11.47 * \sqrt{13} * 4 * 2\sqrt{7}}{3.63} = 241.13$$



[6] the System is type 1

$$\Rightarrow e_{ss} = \frac{1}{K_v}$$

$$K_v = \lim_{S \to 0} S\,G(s)$$

$$= \lim_{S \to 0} \frac{S(S+3.1) * 241.13}{S(S+3)(S+6)(S+12.93}$$

$$= 3.21$$

$$\Rightarrow e_{ss} = \frac{1}{3.21} = 0.31$$

required $e_{ss} \leq 0.1$

desired $e_{ss} = 0.1 \Rightarrow K_v = \frac{1}{e_{ss}} = 10$

$K_{un} = 3.21$; $K_c = 10$

$$\beta = \frac{K_c}{K_{un}} * 1.1 = \frac{10}{3.21} * 1.1 = 3.426$$

$$z_{c_2} = \frac{10}{100} p_2 = 0.1 * -3 = -0.3$$

$$p_{c_2} = \frac{z_c}{\beta} = \frac{-0.3}{3.426} = -0.875$$

$$G_{c\ Lag} = \frac{S+0.3}{S+0.875} \Rightarrow G_s = \frac{241.13(S+3.1)(S+0.3)}{S(S+0.875)(S+3)(S+6)(S+12.93)}$$

Controlled